

# CominLabs Project

## Linking Media in Acceptable Hypergraphs

### Final Report

#### Overall objectives

Available multimedia content is rapidly increasing in scale and diversity, yet today, multimedia data remain mostly unconnected, i.e., with no explicit links between related fragments. LIMAH aimed at exploring hypergraph structures for multimedia collections, instantiating actual links between fragments of multimedia documents, where links reflect particular content-based proximity—similar content, thematic proximity, opinion expressed, answer to a question, etc. Exploiting and developing further techniques targeting segmentation and pairwise comparison of multimedia content, LIMAH was designed to address two key issues of content-based graph-oriented multimedia collection structuring: How to automatically build from a collection of documents a hypergraph, i.e., a graph combining edges of different natures, which provides exploitable links in selected use cases? How collections with explicit links modify usage of multimedia data in all aspects, from a technology point of view as well as from a user point of view?

Two application domains provide particularly interesting playgrounds for hyperlinked media data, namely education with online courses or tutorials, and news with large heterogeneous collections of articles, social posts, podcasts, etc.

LIMAH developed methodology and technology for the automatic or semi-automatic structuring of multimedia collections. Two crucial aspects were considered: on the one hand, segmentation is instrumental in finding the granularity at which links should be created; on the other hand, actual linking is needed at scale and in view of its impact on practices.

Segmentation was mainly studied on educational videos, focusing on how the visualization of the video segments and structure affects learners in memorization and seeking tasks. This research question, which had seldom been considered before, also offers significant insight on the granularity at which links should be created in this type of material, for which understanding the relationships between several videos remains of limited interest. In the news domain, standard topic segmentation algorithms were used. On the contrary, linking was mostly studied in the news domain where the amount of data plainly justifies automatic link creation. We explored hypergraph construction techniques in close relation with acceptability and usage. The key idea was to provide structured collections, with various types of links along with their characterization, and study their impact from multiple angles: relevance of the links, added-value on final tasks, exploitability by users, as well as sociological and legal implications.

#### Main achievements

The LIMAH project has contributed a number of fundamental results in multimedia content processing and linking, impact of segmentation of educational material on learning, and exploration of multimedia news archives from the technical, legal and sociological standpoints. We briefly recap hereunder the main findings.

#### Segmentation and learning

Video content analysis makes it possible to display the structure of the video based on topic segments and table of contents, also known as scaffolding. One goal pursued in LIMAH was to assess whether or not those scaffolding tools can improve information seeking or learning. Five studies



were conducted with students to evaluate different facets of the effect of structuring (i.e., table of contents) and segmentation (i.e., markers on the timeline) on performance in a video-based environment:

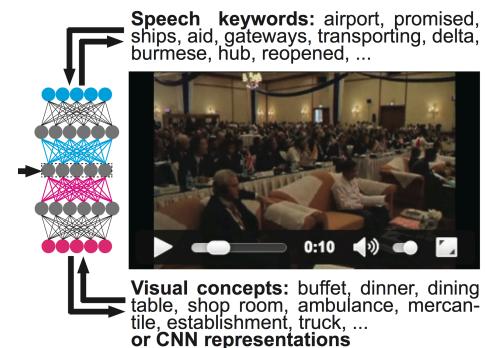
- Three studies investigated the effects video scaffolding on information seeking. Results showed a significant positive effect, consistent across the studies, on response time and task completion, however only when the segmentation and the structuring are both present [4,9]. The presentation format of these two levels of scaffolding was also tested. The perceived difficulty of the task seems to decrease when segmentation and structuring are presented in a pop-up format on the timeline.
- Two studies targeted a learning task where memorization was tested. The first one confirms the presumed absence of a guaranteed beneficial effect of segmentation and structuring on learning performance. The second one highlights that performing an information seeking task before the learning task was necessary for scaffolding to be beneficial on learning, the information seeking task allowing the learner to engage in an active process. The joint presentation of a table of contents and markers on the timeline has positive effect on recall.

Globally, all these results point at the fact that segmentation and structuring together act like a conceptual model of the video to organize incoming information. During an information-seeking task, they provide an external representation of the video, which helps information retrieval. During a learning task, they guide the organization of the information into a coherent mental model and help the recall in memory [5].

Upcoming work will focus on the impact (and acceptance) of automatic segmentation techniques.

### Multimedia content processing and linking

**Multimodal hyperlinking.** Pursuing previous work in text-based video hyperlinking at IRISA, we proposed several approaches to account for multiple modalities at link creation time. Taking advantage of recent advances in semantic indexing of images, we extended the LDA topic model experimented in [13] to multiple modalities, where objects/concepts present in the keyframes of a video define a second stream of words [8]. In the scope of LIMAH, we also experimented with the state-of-the-art neural network based multimodal embedding technique that we developed in a companion thesis [10]. The various multimodal hyperlinking techniques investigated in LIMAH were systematically evaluated in the framework of an international benchmark on video hyperlinking, part of TRECVID from 2015 to 2017 [17,18,19]. In particular, we obtained top results in the 2016 competition. In addition to link relevance, as considered in the video hyperlinking competition, user studies performed in LIMAH demonstrated that multimodal methods, based on either LDA or neural network embedding, offer significant advantages regarding the diversity of links automatically proposed for a given anchor segment [8].



**Navigable multimedia graphs.** The many tools that exist for information extraction do not offer an easy way to gain insight from a news collection by browsing, going from article to article and viewing unaltered original content. Such browsing tools require the creation of rich underlying structures such as graph representations with articles as nodes, which can further be enhanced by typing links to inform users on the nature of the relation between two articles. We empirically observed in previous work that typical  $k$  and  $\epsilon$  nearest neighbor graphs are not well suited for navigation. In LIMAH, we defined explicit navigability criteria for the exploration of a news graph and experimentally highlighted the limits of  $k$  and  $\epsilon$  nearest neighbor graphs, whose limitation comes from the need to define a common threshold ( $k$  or  $\epsilon$ ) for the whole collection [7]. Inspired by work



on community detection in social networks, we developed an adaptive nearest neighbor graph construction algorithm where the neighborhood of an article is of adaptive size, depending on local properties, offering significantly better properties in term of navigation (relevance of neighbors, limited number of neighbors, number of connected components, etc.) [6]. To facilitate the comprehension by users of the links automatically created and the resulting organization of the collection, we proposed a typology of the links as well as heuristics for their automatic categorization [15,7]. All of these features are at the core of the LIMAH news navigation interface that we developed and tested.

**Opinion mining.** Regarding the problem of characterizing and synthesizing opinions expressed in social media, we addressed the problem of robustness. We showed inconsistencies in common opinion mining approaches based on predefined opinion lexicons [11]. More precisely, we have shown that techniques devoted to lexical similarity, like word embedding, do not perform well to retrieve words with similar sentiment properties in general unless significant refinements are undertaken. We also built a reference system for French, independent of the domain, to detect opinion aspects, achieving state-of-the-art results established for English [14]. We finally developed several systems for opinion characterization based on machine learning, including fine-grained categorization, aspect identification, and sarcasm detection on tweets. Several techniques were compared (kNN, CRF, boosted decision trees, deep learning) within the national DeFT benchmark in 2015 [20], 2017 [16], and 2018, where we always ranked in the top five participants. An implementation of a deep-learning system, OpinEx, which gathers the various opinion-mining systems presented to the French DeFT challenges, will soon be made available as a web-service.

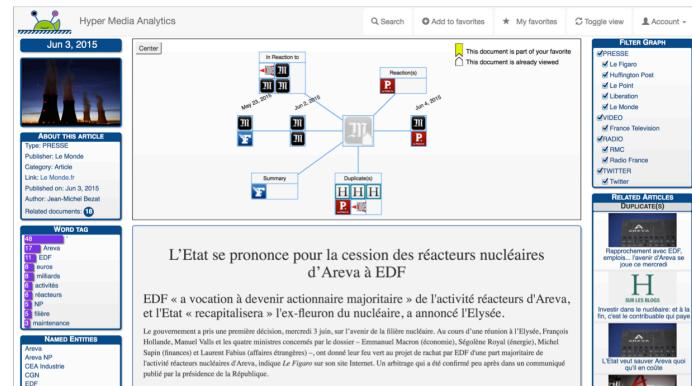
## Exploration of multimedia news archives

### The LIMAH news exploration interface.

Based on the technology available or developed within LIMAH, a pre-study relying on extensive interviews with media professionals, mockup interfaces and human-centered design methodology enabled to analyze the perceived usefulness of a number of functionalities and to select those to be integrated within [the LIMAH interface](#) [12,26]. The starting point of this interface is a full-fledged search bar using keywords.

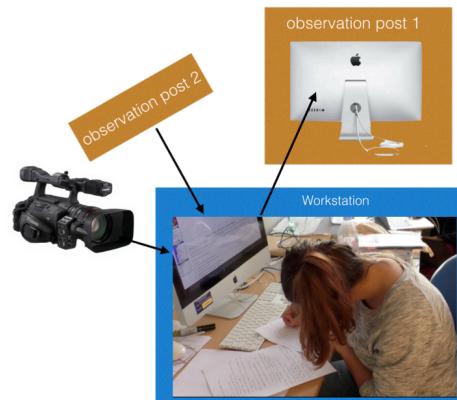
Selecting an entry point in the search result brings the user to the content visualization and navigation part of the interface, composed of 5 parts. The user can initially see the entry point document itself and the links that departs from it. In addition to the original content, metadata and keywords are displayed. Links appear in one of two ways. The graph view quickly shows how related documents appear on a navigable section, facilitating the comprehension of the development of a story. For convenience, on the right side, links are also provided as a list of recommendations organized by link types.

The interest of graph-based collection structuring with possibly typed links was assessed in a user study comparing 3 versions of the interface: Version 1 was limited to a search engine; Version 2 provided the graph structure with only temporal order (no link typing); Version 3 had all features. Each version was tested by a group of users who were asked to produce an exhaustive synthesis on a particular topic. Results show that on average, versions 2 and 3 allowed users to retrieve more pieces of information than version 1. Version 3 moreover allowed retrieving rare pieces of information, also requiring users to skim less documents than with version 2. This indicates that improved explorability thanks to typed links primarily helps users better select which articles to read [7,24]. During the open discussion following the tests, users from version 3 were mostly positive about their experience with



the tool, calling it “useful”, with a “good accessibility”, and an “interesting take on recommendation”.

**Study of practices with an exploration tool.** Complementing user tests on effectiveness of hypergraph-based exploration, we performed a study of practices fostered with such interfaces, working on the process of research-production, i.e., jointly searching for information and producing an output. The study involved 9 professionals from different fields of activity (journalists, PhD student, librarian, community manager, etc.) who were monitored using the news exploration interface over multiple sessions spread in time, during which they were asked to write a synthesis on a topic (summary, working notes, diagram, etc.). Monitoring involved logging in screen activity and audiovisual recording of the sessions. First, our analysis of practices confirms the constant back and forth between exploration and precise querying, the hypergraph being mostly used for exploration. We also observed that users need less time to accomplish their research-production with the LIMAH interface than with their usual tools. But, we found it difficult to differentiate effects of the database size (limited amount of information w.r.t. the web) from those of the hypergraph representation. Lastly, the majority of the professionals showed interest in the hypergraph organization of a collection for their daily practice, provided that they could organize their own database. Unsupervised and dynamic ingestion of new content however remains a perspective of the project.



**Characterization of the legal status of hyperlinks.** The EU law on hyperlinking consists today of a set of pre-existing or developing legal rules. The legal literature has already had the opportunity to work occasionally on the different legal regimes addressing hyperlinking, especially in the field of copyright, without, however, systematizing it as a whole at the EU Level.

In LIMAH, we made an attempt at identifying the overall coherence of those regimes. From a conceptual and synthetic point of view, we evidence the distinction that allows to understand and justify the freedom to link and its limits under the current EU Internet law.

When law sees the link as a pure instrument that facilitates the process of communication, it can be freely established. From, an analytical point of view, this explains why the legal status of hyperlinking under EU intellectual property law tends to be in accordance with the freedom to create links. It also justifies that intermediaries involved in the creation of links, as search engine, content aggregators and social media, can benefit from the limited liability for third party content.

On the contrary, when links become autonomous from the linked content, it logically implies that EU law tends to consider that the hyperlink in itself can be regulated. In this case, hyperlinking is no longer seen only as a reference that provides access to certain content but also, and especially when aggregated, as a direct representation of the information that exists on Internet. This explains the specific limit of the freedom to link because of EU copyright law, the limited protection of hyperlink through copyright, as well as the emerging regulation of hyperlink in itself regarding the diffusion of information. The right to be de-listed or the recent debates on “fake news” are examples of this regulation. Nevertheless, the EU approach remains largely unstable and unachieved, and LIMAH is an attempt at improving its coherence.

## Summary and perspectives

We have globally achieved our goals of structuring collections with links to facilitate their exploration, looking at all aspects (technological, legal and sociological) of the question in a



pluridisciplinary manner and resulting in several joint publications. In addition to the scientific findings and knowledge gained, LIMAH has been the occasion to confront fundamental work with real-life settings and to develop a close relationship with the media world (strong collaboration with Ouest-France and AFP, with IEP Rennes).

All of these offer several opportunities, among which:

- The iCODA project<sup>a</sup>, led by IRISA and involving media groups (AFP, Le Monde, Ouest France), extends the work of LIMAH in the news media domain, considering multimedia content analysis, knowledge engineering and heterogeneous data access to develop interfaces for the seamless exploration of content, data and knowledge in data journalism
- The LIMAH navigation interface is about to be adapted to the needs of DGA, in particular regarding open-source intelligence gathering in the defense business, with a pilot study funded by DGA to be implemented late 2018 / early 2019
- Work on legal aspects by IMT Atlantique led to their participation in a follow-up project proposal on editorial strategies based on data-rich augmented forms, where economic and legal aspects have a key role

## Publications

### PhD theses

[1] Rémi Bois. [Hypergraphes multimédias dirigés navigables : construction et exploitation](#). PhD thesis, University of Rennes 1, December 2017

[2] Salomé Cojean. Effets de la segmentation et de la structuration de vidéos éducatives sur l'apprentissage et la recherche d'information. PhD thesis, Université Rennes 2, scheduled October 2018.

[3] Thomas Pérennou. L'appréhension des hyperliens par le droit de l'union européenne. PhD thesis, Université Rennes 1, scheduled October 2018.

### Peer-reviewed journals

[4] Salomé Cojean, Éric Jamet. [Facilitating Information-Seeking Activity in Instructional Videos: The Combined Effects of Micro- and Macrocaffolding](#). Computers in Human Behavior, Vol. 74, 2017

### Peer-reviewed international conferences

[5] Salomé Cojean, Éric Jamet. [The Impact of Scaffolding on Characteristics of Mental Models During Information-Seeking Activity](#). E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, pp. 292—296, 2017

[6] Rémi Bois, Guillaume Gravier, Éric Jamet, Emmanuel Morin, Maxime Robert, Pascale Sébillot. [Linking Multimedia Content for Efficient News Browsing](#). Annual ACM International Conference on Multimedia Retrieval (ICMR), 2017

[7] Rémi Bois, Guillaume Gravier, Éric Jamet, Maxime Robert, Emmanuel Morin, Pascale Sébillot. [Language-based Construction of Explorable News Graphs for Journalists](#). Empirical Methods in Natural Language Processing - Workshop on Natural Language Processing meets Journalism (EMNLP), 2017

[8] Rémi Bois, Vedran Vukotić, Anca-Roxana Simon, Ronan Sicre, Christian Raymond, Pascale Sébillot, Guillaume Gravier. [Exploiting multimodality in video hyperlinking to improve target diversity](#). International Conference on Multimedia Modelling (MMM), 2017

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<sup>a</sup> Inria Project Lab [Knowledge-mediated integrated content and data analytics](#), 2017—2021.



[9] Salomé Cojean, Éric Jamet. [Facilitating the Information Seeking Activity in Instructional Video: The Effects of Micro- and Macro-scaffolding](#). European Association for Research and Instruction SIG 6&7 "Instructional Design" and "Learning and Instruction with Computers", 2016

[10] Vedran Vukotić, Christian Raymond, Guillaume Gravier. [Bidirectional Joint Representation Learning with Symmetrical Deep Neural Networks for Multimodal and Crossmodal Applications](#). ACM International Conference in Multimedia Retrieval (ICMR), 2016

[11] Grégoire Jadi, Vincent Claveau, Béatrice Daille, Laura Monceaux-Cachard. [Evaluating Lexical Similarity to build Sentiment Similarity](#). Language Resources and Evaluation Conference (LREC), 2016

[12] Guillaume Gravier, Martin Ragot, Laurent Amsaleg, Rémi Bois, Grégoire Jadi, Éric Jamet, Laura Monceaux, Pascale Sébillot. [Shaping-Up Multimedia Analytics: Needs and Expectations of Media Professionals](#). International Conference on Multimedia Modelling (MMM), 2016

[13] Anca-Roxana Simon, Rémi Bois, Guillaume Gravier, Pascale Sébillot, Emmanuel Morin, Sien Moens. [Hierarchical Topic Models for Language-based Video Hyperlinking](#). ISCA/IEEE Workshop on Speech, Language and Audio in Multimedia (SLAM), 2015

#### Peer-reviewed national conferences

[14] Grégoire Jadi, Laura Monceaux, Vincent Claveau, Béatrice Daille. [Opinion Target Expression extraction: from English to French](#). Conf. Traitement automatique des langues naturelles (TALN), 2016

[15] Rémi Bois, Guillaume Gravier, Pascale Sébillot, Emmanuel Morin. [Vers une typologie de liens entre contenus journalistiques](#). Conf. Traitement automatique des langues naturelles (TALN), short paper, 2015

#### Non-reviewed workshop communications

[16] Vincent Claveau, Christian Raymond. [Participation de l'IRISA à DeFT2017 : systèmes de classification de complexité croissante](#), Workshop Défi Fouille de Texte (DEFT), 2017

[17] Mikail Demirdelen, Mateusz Budnik, Gabriel Sargent, Rémi Bois, Guillaume Gravier. [IRISA at TRECVID 2017: Beyond Crossmodal and Multimodal Models for Video Hyperlinking](#). TRECVID Workshop, 2017

[18] Rémi Bois, Vedran Vukotić, Ronan Sicre, Christian Raymond, Guillaume Gravier, Pascale Sébillot. [IRISA at TrecVid2016: Crossmodality, Multimodality and Monomodality for Video Hyperlinking](#). TRECVID Workshop, 2016

[19] Anca-Roxana Simon, Ronan Sicre, Rémi Bois, Pascale Sébillot, Guillaume Gravier. [IRISA at TrecVid2015 : Leveraging Multimodal LDA for Hyperlinking](#). TRECVID Workshop, 2015

[20] Vedran Vukotić, Vincent Claveau, Christian Raymond. [IRISA at DeFT 2015: Supervised and Unsupervised Methods in Sentiment Analysis](#). Workshop Défi Fouille de Texte (DEFT), 2015

[21] Nicolas Hernandez, Grégoire Jadi, Joseph Lark, Laura Monceaux. [Exploitation de lexiques pour la catégorisation fine d'émotions, de sentiments et d'opinions](#). Workshop Défi Fouille de Texte (DEFT), 2015

#### Poster presentations

[22] Salomé Cojean, Éric Jamet. [Quels outils pour favoriser la recherche d'information dans les vidéos ? Effets sur les performances et les représentations mentales](#). Savoir, apprentissage, éducation aujourd'hui : Regards croisés en sciences humaines et sociales, Journées transversales de l'UFR Sciences Humaines de Rennes 2, 2017



## **Technical reports**

- [23] Sophie Barel, Florian Hémont. [Pratiques de recherches-productions et outil d'exploration.](#) Technical report, PREFics, 2018
- [24] Maxime Robert. [Évaluation de l'interface LIMAH : tests utilisateurs.](#) Technical report, CRPCC, 2016
- [25] Maxime Robert. [Analyse des fonctionnalités proposées par des experts scientifiques vs. des professionnels.](#) Technical report, CRPCC, 2016
- [26] Martin Ragot. [Étude amont de l'interface LIMAH.](#) Technical report, CRPCC, 2016
- [27] Rémi Bois. [Le corpus LIMAH.](#) Technical report, IRISA, 2016

## **Invited talks**

Guillaume Gravier. Structuring multimedia collections with links for media analytics. Invited conference at Universidad de Chile, 2017

Pascale Sébillot, Tristan Allard. [Définition informatique de la donnée numérique et perceptions des contraintes de propriétés intellectuelles.](#) Colloque Propriété intellectuelle et données dans l'environnement numérique. Faculté de droit et de science politique, 2017

Guillaume Gravier. Structuring multimedia collections with links for media analytics. Invited conference at Katholieke Universiteit Leuven, 2017

Guillaume Gravier. Structuring multimedia collections with links for media analytics. Invited talk at ACM Multimedia TPC Workshop, 2016

Annie Blandin. Un nouveau cadre législatif pour le Marché unique numérique, Colloque Digital Single Market - 8es Rencontres de la Maison de l'Europe, 2015

